DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

14 CFR Part 25

[Docket No. FAA-2021-1023; Special Conditions No. 25-811-SC]

Special Conditions: The Boeing Company, Model 737-10 Airplane; Dynamic Test Requirements for Single-Occupant, Oblique (Side-Facing) Seats Installed at 49 Degrees with Airbag Devices and 3-Point Restraints

AGENCY: Federal Aviation Administration (FAA), Department of Transportation (DOT).

ACTION: Final special conditions.

SUMMARY: These special conditions are issued for The Boeing Company (Boeing) Model 737-10 airplane. This airplane will have a novel or unusual design feature when compared to the state of technology envisioned in the airworthiness standards for transport-category airplanes. This design feature is single-occupant oblique seats with airbag devices and 3-point restraints, installed at 49 degrees relative to the airplane cabin bow-to-stern centerline. The applicable airworthiness regulations do not contain adequate or appropriate safety standards for this design feature. These special conditions contain the additional safety standards that the Administrator considers necessary to establish a level of safety equivalent to that established by the existing airworthiness standards.

DATES: Effective [INSERT DATE OF PUBLICATION IN THE FEDERAL REGISTER].

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SUPPLEMENTARY INFORMATION:

Background

On January 30, 2019, Boeing applied for a change to Type Certificate No. A16WE for the installation of single-occupant oblique seats, with airbag devices and 3-point restraints, installed at 49 degrees relative to the airplane cabin bow-to-stern centerline in the Boeing Model 737-10 airplane. The Boeing Model 737-10 airplane is a twin-engine, transport-category airplane with seating for 230 passengers and a maximum takeoff weight of 197,900 pounds.

Type Certification Basis

Under the provisions of 14 CFR 21.101, Boeing must show that the Model 737-10 airplane, as changed, continues to meet the applicable provisions of the regulations listed in Type Certificate No. A16WE, or the applicable regulations in effect on the date of application for the change, except for earlier amendments as agreed upon by the FAA.

If the Administrator finds that the applicable airworthiness regulations (e.g., 14 CFR part 25) do not contain adequate or appropriate safety standards for the Boeing Model 737-10 airplane because of a novel or unusual design feature, special conditions are prescribed under the provisions of § 21.16.

Special conditions are initially applicable to the model for which they are issued. Should the type certificate for that model be amended later to include any other model that incorporates the same novel or unusual design feature, or should any other model already included on the same type certificate be modified to incorporate the same novel or unusual design feature, these special conditions would also apply to the other model under § 21.101.

In addition to the applicable airworthiness regulations and special conditions, the Boeing Model 737-10 airplane must comply with the fuel-vent and exhaust-emission

requirements of 14 CFR part 34, and the noise-certification requirements of 14 CFR part 36.

The FAA issues special conditions, as defined in § 11.19, in accordance with § 11.38, and they become part of the type certification basis under § 21.101.

Novel or Unusual Design Features

The Boeing Model 737-10 airplane will incorporate the following novel or unusual design feature:

Single-occupant oblique seats, with airbag devices and 3-point restraints, installed at 49 degrees relative to the airplane cabin bow-to-stern centerline.

Discussion

Section 25.785(d) requires that each occupant of a seat installed at an angle of more than 18 degrees, relative to bow-to-stern airplane cabin centerline, must be protected from head injury using a seatbelt and an energy-absorbing rest that supports the arms, shoulders, head, and spine; or using a seatbelt and shoulder harness designed to prevent the head from contacting any injurious object.

The Boeing Model 737-10 airplane single-occupant oblique seat installation, with airbag devices and 3-point restraints, is novel such that the current requirements do not adequately address airbag devices and protection of the occupant's neck, spine, torso, and legs for seating configurations that are positioned at an angle of 49 degrees from the airplane centerline. The seating configuration installation angle is beyond the installation-design limits of current special conditions issued for seat positions at angles between 18 degrees and 45 degrees. For example, at these angles, lateral neck bending and other injury mechanisms prevalent from a fully side-facing installation become a concern. Although special conditions no. 25-552-SC was issued for Boeing Model 787 airplane seats installed at 49 degrees in 2014, that document is no longer applicable because they were issued prior to the current oblique-seat special conditions that are based on the July

11, 2018, FAA policy statement PS-AIR-25-27, "Technical Criteria for Approving Oblique Seats." These special conditions are based on the Boeing Model 787 airplane special conditions, with updates from that policy statement, and to align with the fully side-facing-seat policy statement PS-ANM-25-03-R1, "Technical Criteria for Approving Side-Facing Seats."

To provide a level of safety equivalent to that afforded to occupants of forward- and aft-facing seats, additional airworthiness standards, in the form of dynamic testing requirements, including both the injury criteria limits from the oblique-seat policy and the fully side-facing-seat policy through new special conditions, are necessary.

The special conditions contain the additional safety standards that the Administrator considers necessary to establish a level of safety equivalent to that established by the existing airworthiness standards.

Discussion of Comments

The FAA issued Notice of Proposed Special Conditions No. 25-21-05-SC for the Boeing Model 737-10 airplane, which was published in the *Federal Register* on December 15, 2021 (86 FR 71183). The FAA received one comment from the Air Line Pilots Association, International, in support of the special conditions.

Applicability

As discussed above, these special conditions are applicable to the Boeing Model 737-10 airplane. Should Boeing apply at a later date for a change to the type certificate to include another model incorporating the same novel or unusual design feature, these special conditions would apply to that model as well.

Conclusion

This action affects only a certain novel or unusual design feature on one model of airplane. It is not a rule of general applicability.

List of Subjects in 14 CFR Part 25

Aircraft, Aviation safety, Reporting and recordkeeping requirements.

Authority Citation

The authority citation for these special conditions is as follows:

Authority: 49 U.S.C. 106(f), 106(g), 40113, 44701, 44702, 44704.

The Special Conditions

Accordingly, pursuant to the authority delegated to me by the Administrator, the following special conditions are issued as part of the type certification basis for Boeing Model 737-10 airplanes.

In addition to the requirements of §§ 25.562 and 25.785, passenger seats with airbag devices and 3-point restraints, installed at an angle 49 degrees relative to the airplane cabin bow-to-stern centerline, must meet the following:

a. Head Injury Criteria (HIC)

HIC assessments are required only for head contact with the seat and other structure.

1. Compliance with § 25.562(c)(5) is required, except that, because an airbag device is present in addition to the 3-point restraint system, when the anthropomorphic test dummy (ATD) has no apparent contact with the seat and other structure but has contact with the airbag, a HIC score in excess of 1000 is acceptable, provided the HIC15 score (calculated in accordance with 49 CFR 571.208) for that contact is less than 700.
2. ATD head contact with the seat or other structure through the airbag, or contact subsequent to contact with the airbag, requires an HIC value not exceeding 1000.
3. The HIC value must not exceed 1000 in any condition in which the airbag does or does not deploy, up to the maximum severity pulse specified by the existing requirements.
4. To accommodate a range of occupant heights (5th percentile female to 95th percentile male), any surface, airbag or otherwise, that provides support for the

occupant head, must provide that support in a consistent manner regardless of occupant stature. Otherwise, additional HIC assessment tests may be needed.

b. Body-to-Wall/Furnishing Contact

If a seat is installed aft of structure, such as an interior wall or furnishing that does not provide a homogenous contact surface for the expected range of occupants and yaw angles, then additional analysis and tests may be required to demonstrate that the injury criteria are met for the area an occupant could contact. For example, different yaw angles could result in different injury considerations and airbag performance, and may require additional analysis, or separate tests may be necessary to evaluate performance.

c. Neck Injury Criteria

1. The seating system must protect the occupant from experiencing serious neck injury. The assessment of neck injury must be conducted with the airbag device activated, unless there is reason to also consider that the neck injury potential would be higher for impacts below the airbag-device deployment threshold.
2. Rotation of the head about its vertical axis, relative to the torso, is limited to 105 degrees in either direction from forward-facing.
3. The neck must not impact any surface that would produce concentrated loading on the neck.
4. Assess neck injury for fore and aft neck bending using the FAA Hybrid III ATD, as described in SAE 1999-01-1609, "A Lumbar Spine Modification to the Hybrid III ATD for Aircraft Seat Tests," applying the following criteria:

The N_{ij}, calculated in accordance with 49 CFR 571.208, must be below 1.0, where $N_{ij} = F_z/F_{zc} + M_y/M_{yc}$, and N_{ij} critical values are:

F_{zc} = 1,530 lbs (6805 N) for tension

F_{zc} = 1,385 lbs (6160 N) for compression

M_{yc} = 229 lb-ft (301 Nm) in flexion

M_{yc} = 100 lb-ft (136 Nm) in extension

In addition, peak upper-neck F_z must be below 937 lbs (4168 N) in tension and 899 lbs (3999 N) in compression.

5. When lateral neck bending is present, assess it using an ES-2re ATD as defined by 49 CFR part 572, subpart U. The data must be filtered at channel frequency class (CFC) 600 as defined in SAE Recommended Practice J211-1, "Instrumentation for Impact Test Part 1-Electrionic Instrumentation:"
    i. The upper-neck tension force at the occipital condyle (O.C.) location must be less than 405 lbs (1,800 N).
    ii. The upper-neck compression force at the O.C. location must be less than 405 lbs (1,800 N).
    iii. The upper-neck bending torque about the ATD x-axis at the O.C. location must be less than 1,018 in-lbs (115 Nm).
    iv. The upper-neck resultant shear force at the O.C. location must be less than 186 lbs (825 N).

d. Spine and Torso Injury Criteria
    1. The seating system must protect the occupant from experiencing spine and torso injury. The assessment of spine and torso injury must be conducted with the airbag device activated, unless it is necessary to also consider that the occupant-injury potential would be higher for impacts below the airbag-device deployment threshold.
    2. Assess spine and torso injury, for oblique torso bending, using the FAA Hybrid III ATD, applying the following criteria:
        i. The lumbar spine tension (F_z) cannot exceed 1,200 lbs (5338 N).

ii. Significant concentrated loading on the occupant's spine, in the area between the pelvis and shoulders during impact, including rebound, is not acceptable. During this type of contact, the interval for any rearward (X direction) acceleration exceeding 20g must be less than 3 milliseconds, as measured by the thoracic instrumentation specified in 49 CFR part 572, subpart E, filtered in accordance with SAE Recommended Practice J211-1.

3. When lateral torso bending is present, assess spine and torso injury using an ES-2re ATD, applying the following criteria:

i. Thoracic: The deflection of any of the ES-2re ATD upper, middle, and lower ribs must not exceed 1.73 inches (44 mm). Process the data as defined in Federal Motor Vehicle Safety Standards (FMVSS) 571.214, title 49 of the CFR.

ii. Abdominal: The sum of the measured ES-2re ATD front, middle, and rear abdominal forces must not exceed 562 lbs (2,500 N). Process the data as defined in FMVSS 571.214.

iii. Upper-torso support: The lateral flexion of the ATD torso must not exceed 40 degrees from the normal upright positions during impact.

e. Pelvic Criteria

1. The seating system must protect the occupant from experiencing pelvis injury.
2. Any part of the load-bearing portion of the bottom of the ATD pelvis must not translate beyond the edges of the seat bottom seat-cushion supporting structure.
3. When pelvis contact with the armrest or surrounding interior components is present, assess it using an ES-2re ATD. The pubic symphysis force measured by the ES-2re ATD must not exceed 1,350 lbs (6,000 N). Process the data as defined in FMVSS 571.214.

f. Femur Criteria

Limit axial rotations of the upper leg (about the z-axis of the femur, per SAE Recommended Practice J211-1) to 35 degrees from the nominal seated position. Evaluation during rebound does not need to be considered.

g. ATD and Test Condition

1. Perform longitudinal tests, conducted to measure the injury criteria above, using the FAA Hybrid III ATD or using the ES-2re ATD. Conduct the tests with the undeformed floor, at the most-critical yaw cases for injury, and with all lateral structural supports (e.g., armrests or walls) installed.
2. For longitudinal tests conducted in accordance with § 25.562(b)(2), to show compliance with the seat-strength requirements of § 25.562(c)(7) and (8), and these special conditions, to ensure proper loading of the seat by the occupant, the ATD pelvis must remain supported by the seat pan, and the restraint system must remain on the pelvis of the ATD until rebound begins. No injury criteria evaluation is necessary for tests conducted only to assess seat-strength requirements.
3. If a seat installation includes adjacent items that are within contact range of an occupant, assess the injury potential of that contact. To make this assessment, tests may be conducted to include the actual contact item, located and attached in a representative fashion. Alternatively, the injury potential may be assessed through a combination of tests with contact items having the same geometry as the actual contact item, but having stiffness characteristics that would create the worst case for injury, such as injuries due to both contact with the item and lack of support from the item.
4. Conduct the combined horizontal and vertical test, required by § 25.562(b)(1) and these special conditions, with the FAA Hybrid II ATD (49 CFR part 572, subpart B, as specified in § 25.562) or equivalent.

5. The design and installation of seatbelt buckles must prevent unbuckling due to applied inertial forces, or impact from seat occupant hands and arms, during an emergency landing.

h. Inflatable Airbag-Restraint System Special Conditions:

An inflatable airbag-restraint system will be installed, and must meet the requirements of Special Conditions No. 25-386-SC, "Boeing Model 737-600/ -700/-700C/-800/-900 and 900ER Series Airplanes; Seats With Inflatable Lapbelts," applicable to Boeing Model 737-10 series airplanes.

i. General Test Guidelines:

1. The determination of the appropriate ATD to be used in assessing occupant injury (FAA Hybrid III or ES-2re) is based on the occupant kinematics at the selected test angle. At the +10-degree yaw angle, the occupant kinematics show that occupant injury tests, using both ATDs, are required.
2. Conduct vertical tests with the Hybrid II ATD or equivalent, with existing pass/fail criteria.
3. Conduct longitudinal structural tests with the Hybrid II ATD or equivalent, deformed floor, with 10 degrees yaw, and with all lateral structural supports (e.g., armrests or walls) required to support the occupant.
4. Conduct longitudinal occupant-injury tests, as necessary, with the FAA Hybrid III ATD or ES-2re ATD, undeformed floor, yaw, and with all lateral structural supports (e.g., armrests or walls) critically represented, and which are within contact range of the occupant.
    i. Pass/fail injury assessments:
        A. Perform HIC, fore and aft neck injury, spinal tension, and femur evaluations using the FAA Hybrid III ATD.

B. Perform lateral neck injury, thoracic, abdominal, pelvis, and femur evaluations using the ES-2re ATD.

5. For injury assessments accomplished by testing with the ES-2re ATD for longitudinal tests conducted in accordance with § 25.562(b)(2) and these special conditions, the ATDs must be positioned, clothed, and have lateral instrumentation configured as follows:

i. ES-2re ATD Lateral Instrumentation:

The rib-module linear slides are directional (i.e., deflection occurs in either a positive or negative ATD y-axis direction). Install the modules such that the moving end of the rib module is toward the front of the airplane. Install the three abdominal-force sensors such that they are on the side of the ATD toward the front of the airplane.

ii. ATD Clothing:

Clothe each ATD in form-fitting cotton-stretch garments with short- to full-length sleeves, mid-calf to full-length pants, and size 11E (45) shoes weighing about 2.5 lbs (1.1 kg), and having a heel height of about 1.5 inches (3.8 cm). The color of the clothing should be in contrast to the color of the restraint system and the background. The color of the clothing should be chosen to avoid overexposing the high-speed images captured during the test. The ES-2re jacket is sufficient for torso clothing, although a form-fitting shirt may be used in addition, if desired.

iii. ATD Positioning:

A. Lower the ATD vertically into the seat while simultaneously:

(1) Aligning the midsagittal plane (a vertical plane through the midline of the body, dividing the body into right and left halves) to approximately the middle of the seat place.

(2) Keeping the upper legs horizontal by supporting them just behind the knees.

(3) Applying a horizontal x-axis direction (in the ES-2re ATD coordinate system) force of about 20 lbs (89 N) to the bottom rib of the ES-2re, to compress the seat-back cushion.

B. After all lifting devices have been removed from the ATD:

(1) Rock it slightly to settle it in the seat.

(2) Bend the knees of the ATD.

(3) Separate the knees by about 4 inches (100 mm).

(4) Set the ATD's head at approximately the midpoint of the available range of z-axis rotation (to align the head and torso midsagittal planes).

(5) Position the ATD's arms at the joints' mechanical detent, to position them to an approximately 20- to 40-degree angle with respect to the torso.

(6) Position the feet such that the centerlines of the lower legs are approximately parallel.

Note: Seats installed via plinths or pallets must meet all applicable requirements. Compliance with the guidance contained in policy memorandum PS-ANM-100-2000-00123, "Guidance for Demonstrating Compliance with Seat Dynamic Testing for Plinths and Pallets," dated February 2, 2000, is acceptable to the FAA.

Issued in Kansas City, Missouri, on February 8, 2022.

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